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Title:	Vessel Clean-out Operations, Simple Overview, Development, and Emptying
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Vessel Clean-out Operations Simple Overview, Development, Emptying

Brandy Royer, J-1

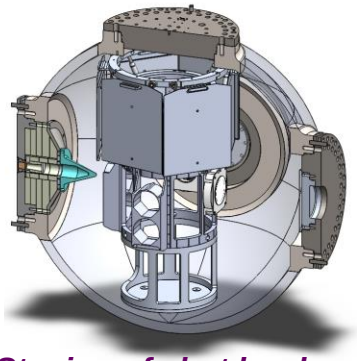
September 2017

General Overview

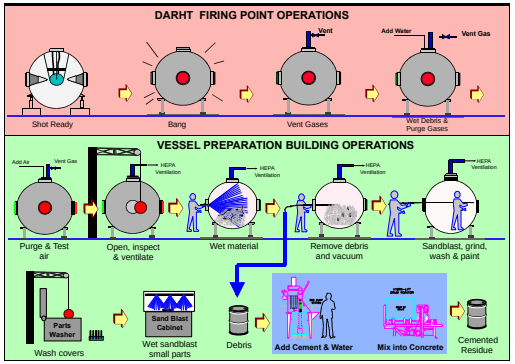
- Facility Design
  - Based on Shot Information (at the time)
  - Regulatory Drivers
- Operation Process
  - Basic Steps
  - Track Effectiveness

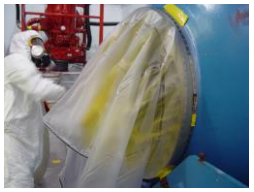
Vessel Life Cycle: Standard Shot 20+ Weeks

Prior to Life Cycle 3-6 months Shot Specific Hardware Design: 6 month Procurement



Staging of shot hardware 5 week build, then install @ DARHT 3 weeks prior to shot





Vessel Clean-out process (Firing Point & VPF)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Vessel Assembly																						
DARHT Ops						3 Week Run up																
Shot																						
Exchange Vessel																						
Firing Point Vessel Work																						
Clean-out VPB																						
Repair and Inspection																						
Return to Service																						

Inspection/Repair/Return to Service

Design Basis

- Minimize Personnel Exposures to Hazards
  - Metal Particulates: Rad, Be, Lead, Reactives

Beryllium:
- 0.2 µg/m^3 Action Level
- 2.0 µg/m^3 PEL
- 0.2 µg/100 cm^2 Surface

Depleted Uranium
- <1 DAC
- 1000 dpm Loose Surface

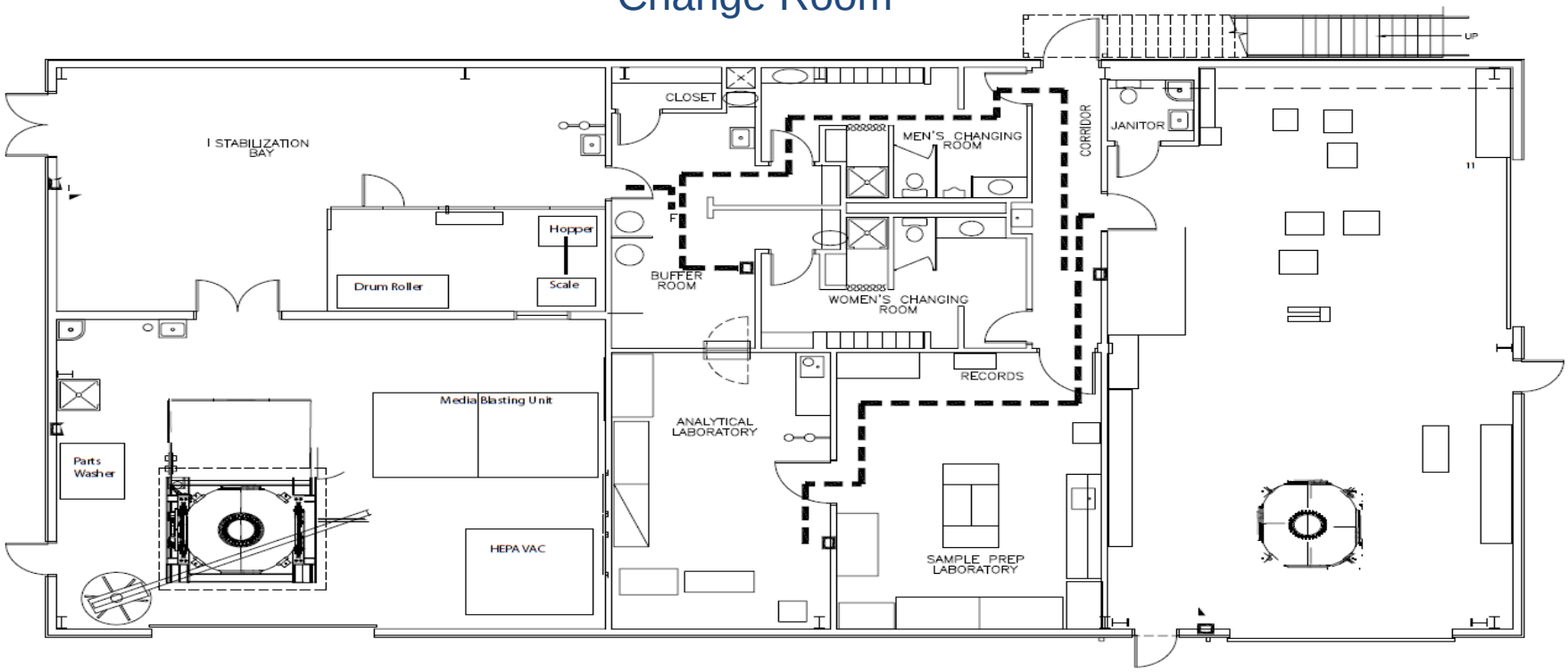
- Minimize Secondary Waste
- Minimize/Eliminate Mixed Waste
- Recover/Decontaminate/Reuse Hardware

Keep it Simple

- Designed Chemical Process
  - Elaborate Equipment
  - Multiple Extraction and Transfer Systems
  - Separation Chemistry
  - No benefit
- Changed Process
  - Minimal Movement of Materials
  - Materials had Value until Declared Waste
    - Stabilization

Vessel Prep Building

Change Room

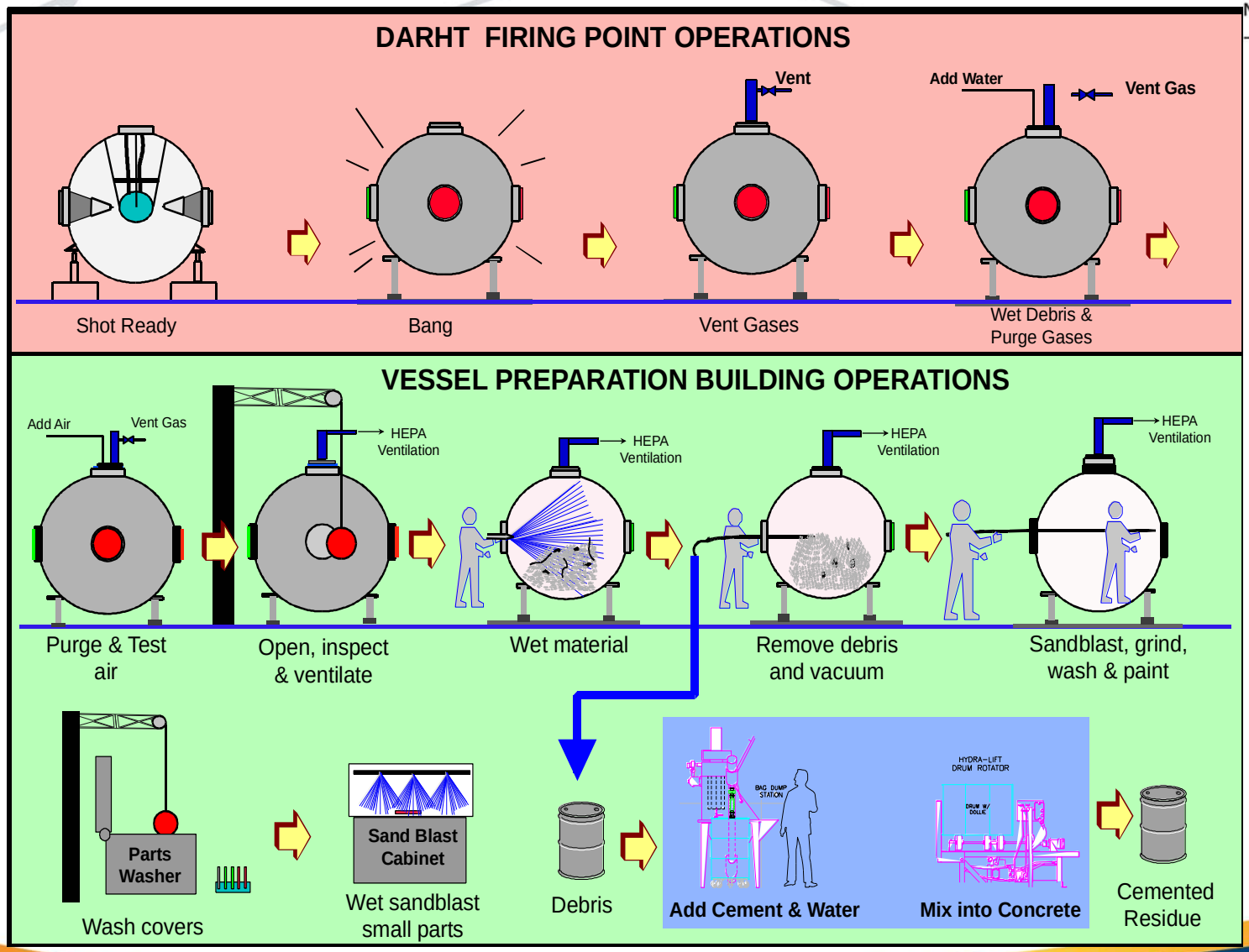


Clean-out & Stabilization

Analysis Lab

Staging Ops

Standard Post Shot Operations

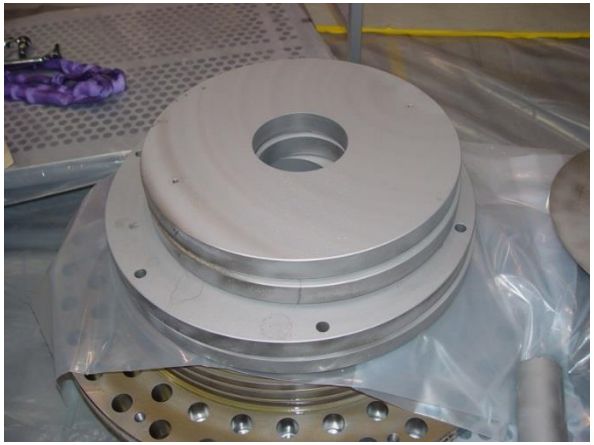


Operations: Engineering, Administrative, PPE Controls

Sanitization

- Cement Finer Material
- Verification Analysis on Waste Streams in House
- Minimize Secondary Waste by Recycling into Process

Decon Vessel and Hardware for Re-use



Inspections

- Vessel for Repairable Damage
  - >0.4 in Depth
  - Inspect thru-holes, re-tap
- Hardware
  - Inspect Covers and Hardware
  - Repair if possible
- Document it All!

Step by Step Clean-Out

- Shot Materials Determine the Process
  - Be, DU, Foams, Reactives, Flammables
  - Recipe Approach: Safe the Vessel
- Initial Design; Issues and Improvements
  - Equipment Details and Effectiveness
  - Improvement Needs
- Current Operation and Timeline
  - Limitations and Future Improvements

Detonation Byproducts

- Hydrophobic Carbonous Residue
  - Pre-add Surfactant
  - 40 L Water
- Explosive and Toxic Gas
  - Evaluated Vacuum
  - Pressurize; Air Exchange
  - Vacuum/Pressure Combo
  - *Continuous Flowthru 96 hrs

Gas	Initial Conc	Final Conc	PEL
CO	20-30%	100 ppm	25 ppm
CH4	3-15%	0.5 %	1000ppm
O2	1-5%	20.9	
H2	28-50%	0.1%	
HCN	1000 ppm	<0.1	4 ppm
Benzene	700 ppm	0.2 ppm	0.5 ppm
Acetone	50 ppm	0.1 ppm	500 ppm
Toluene	50 ppm	<0.1 ppm	50 ppm

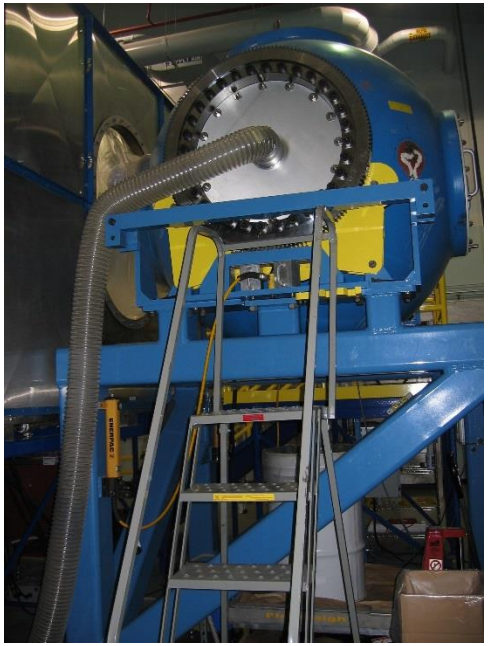
Kitchen Soup Chemistry: *Process Prior to Opening*

- Ideally, pre-add water to vessel
  - Wets residue
  - Mitigates Airborne Particulates Be/DU
  - Mitigates Water Reactives
- Cyanide Miscible in Water
  - Continuous Surface Equilibrium
  - Foams, Urethanes
  - Must Purge First
- Reactives
  - Mitigate before Opening
  - Inert and Inundate with Water
    - Solubility Issues
    - Caustic Solutions pH>14
    - Buffer with CO_2 Gas (takes multiple passes)

Initial Ideas/Failures?

- Minimal Handling
- Slide Gate/ Auguring System
- Wash Down
- Based on Qual Shots-No Shielding

- Forklift Mass
- Insufficient Crane/Reach
- Top Hatch

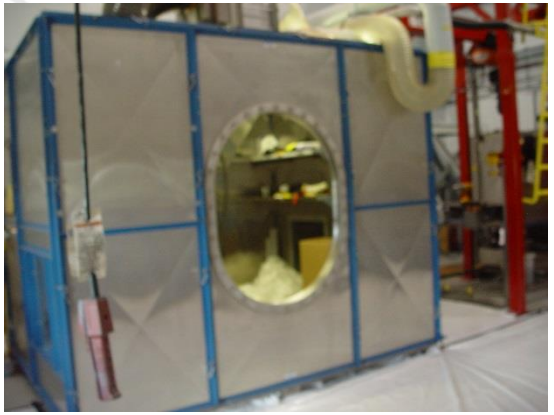


KEEP it SIMPLE

Controls

- Engineering
  - Ventilation
  - PSS System
  - Permacon
  - Bagouts
  - HEPA Vacuums
- Administrative
  - Personal and Area Monitors
  - Confined Space Protocols
  - Keep it Wet! Keep it Clean!
- PPE: Assume Exposure
  - Level II: Double Coveralls, Double Gloves, Hood, Booties, APR-P100
  - Doffing Area
  - Upgrade based on Materials

Setup



- Remove all the Bolts
- Bagout Top Cover and Side Cover
  - Keeps Gases/Particulates Inside Vessel
  - 3 Ton Jib Crane
- Permacon Structure: Hazard Zone

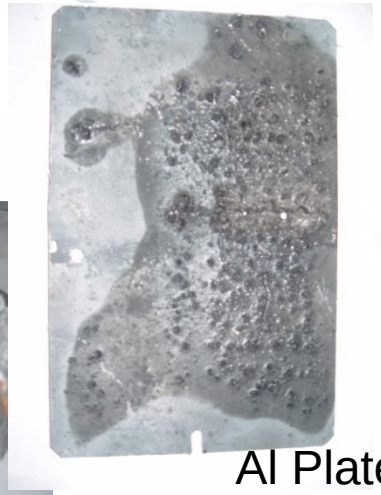
Ventilation

- Dual HEPA Systems
  - 800 CFM
  - Vessel Negative to Work Area
  - Adaptor for Vessel Nozzle
  - PSS Alarm
- Small In-line HEPA Minimize Abrasions from Media System
  - Simple Maintenance

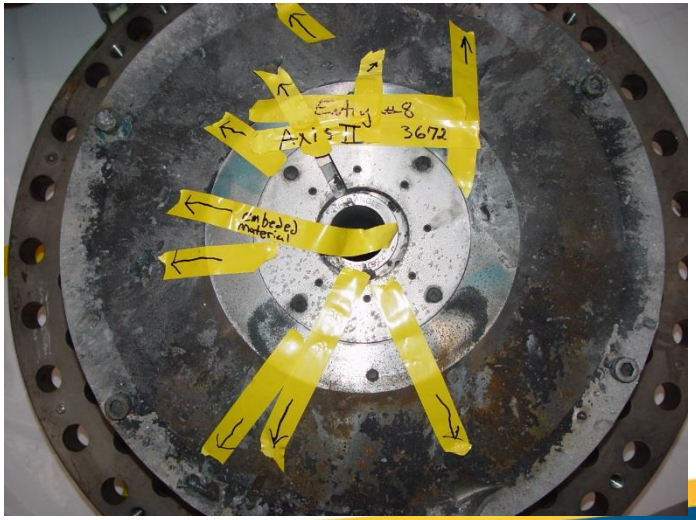
Sort the Shielding

Witness Plates/Forensics

- What Do We Recover?
- Evaluate Shielding Plates
- Collimators
  - Rough Collimators
  - Collimators
- Breach
- Document it All!



Al Plates 1 & 2



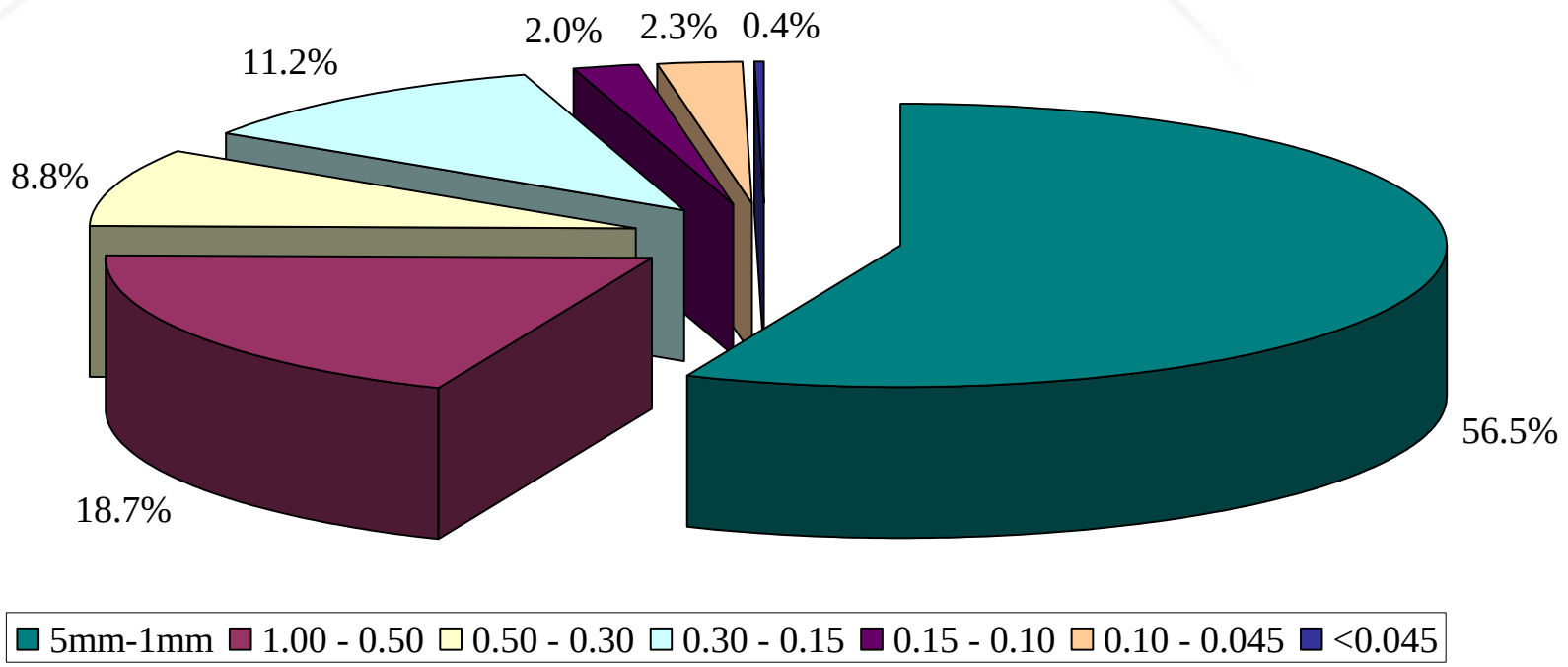
Vacuum the Slurry: Vector Technologies

Drum Drop-out Collection

1000 cfm HEPA

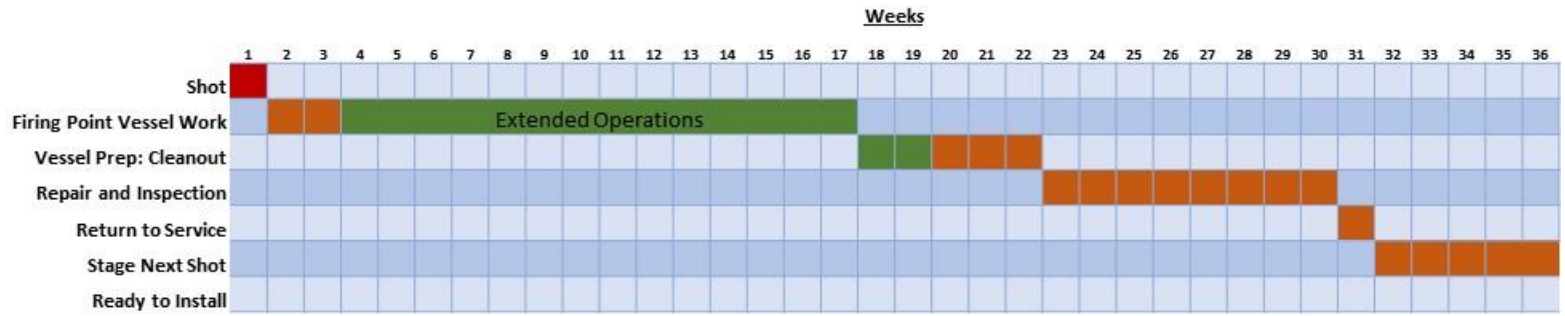
- Vacuum <2 in (5 cm)/Restrict with 3 in Hose
- Drum Drop Collects 99% of Material: Reduces Wear and Tear
- Change Hoses Annually-Abrasion Tears on Occasion
- Localizes Contamination to Permacon

Keep it Wet!


2.0%
2.3%
0.4%
11.2%
8.8%
56.5%
18.7%
5mm-1mm
1.00 - 0.50
0.50 - 0.30
0.30 - 0.15
0.15 - 0.10
0.10 - 0.045
<0.045

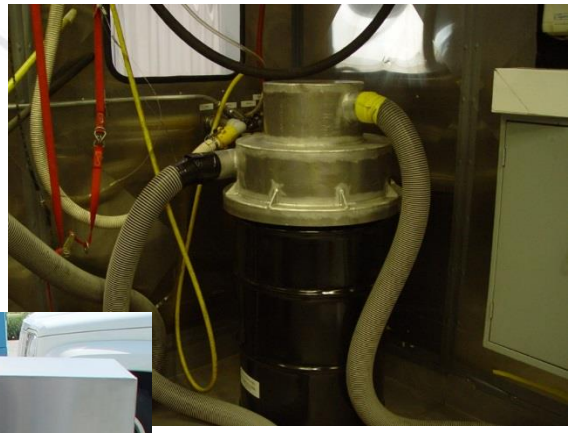
Timeline, Impacts, Lessons Learned

- Materials Drive Operation Timelines
  - Discuss Chemistry Further
  - Building Design Limitations
    - VPB Designed for 250 moles H_2 = 4 kg Limit
    - Results in processing on Firing Point = Schedule Delay
- Solubility Issues-Saturate Solutions = Longer processing time
- VPB Not Designed for Caustic Solutions
  - Caustic Solutions = Neutralization = Longer Processing Time



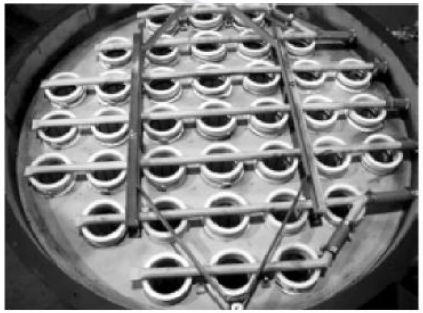
Improve Setup for Collection Drums

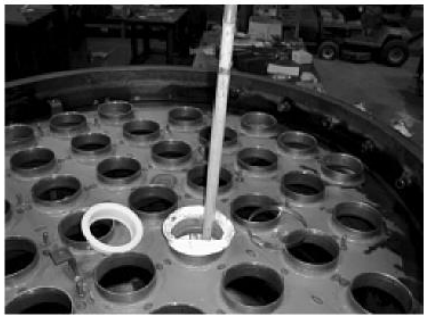
- Temporarily Under Ventilation
- Need Localized Ventilation/Drum Adaptor
  - Exposure Issues
  - Caustic Slurries
  - All “Reactions” Complete
- Balance Water: Aggregate
- Consolidate
  - Materials
  - Wash Waters

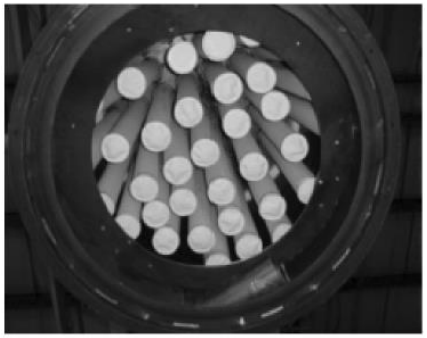


Vector Issues with Wet Processes

- Sock Loading
  - Loss
  - Max Delta
  - Moisture
- Adjust Operations
  - Run Cycle
  - Don’t use as Ventilation
- Regular Maintenance
  - Maintenance Based on Hrs
  - Short Durations/Starts/Stops
  - Monitoring Delta
  - Sock Change Outs







Conclusions

- Simple Approach
  - Engineering Controls, Administrative Controls, PPE
  - Quench Hazards Prior to Opening
    - Further Discuss Chemistry
- Our Lessons Learned
  - Need to Know: Cant Design If You Don’t Know
  - Everything that Goes In, Must Come Out
  - Didn’t Plan for the Future
    - Address New Chemical Hazards
  - Document the Events
  - Regular Maintenance

General Overview

- Describe Tracking and Effectiveness of Decon
  - Contamination Levels and Exposures
  - Design and Process Improvements
  - Problematic Materials
- Describe Process Equipment
  - Past and Current Approaches
  - Decon of Vessel and Decon of Covers/Hardware
- Hardware and Vessel Inspection
- Vessel and Hardware Back into Service
  - Beryllium Analysis
  - Formal Tracking

Fluid Process: Clean-out to Decon

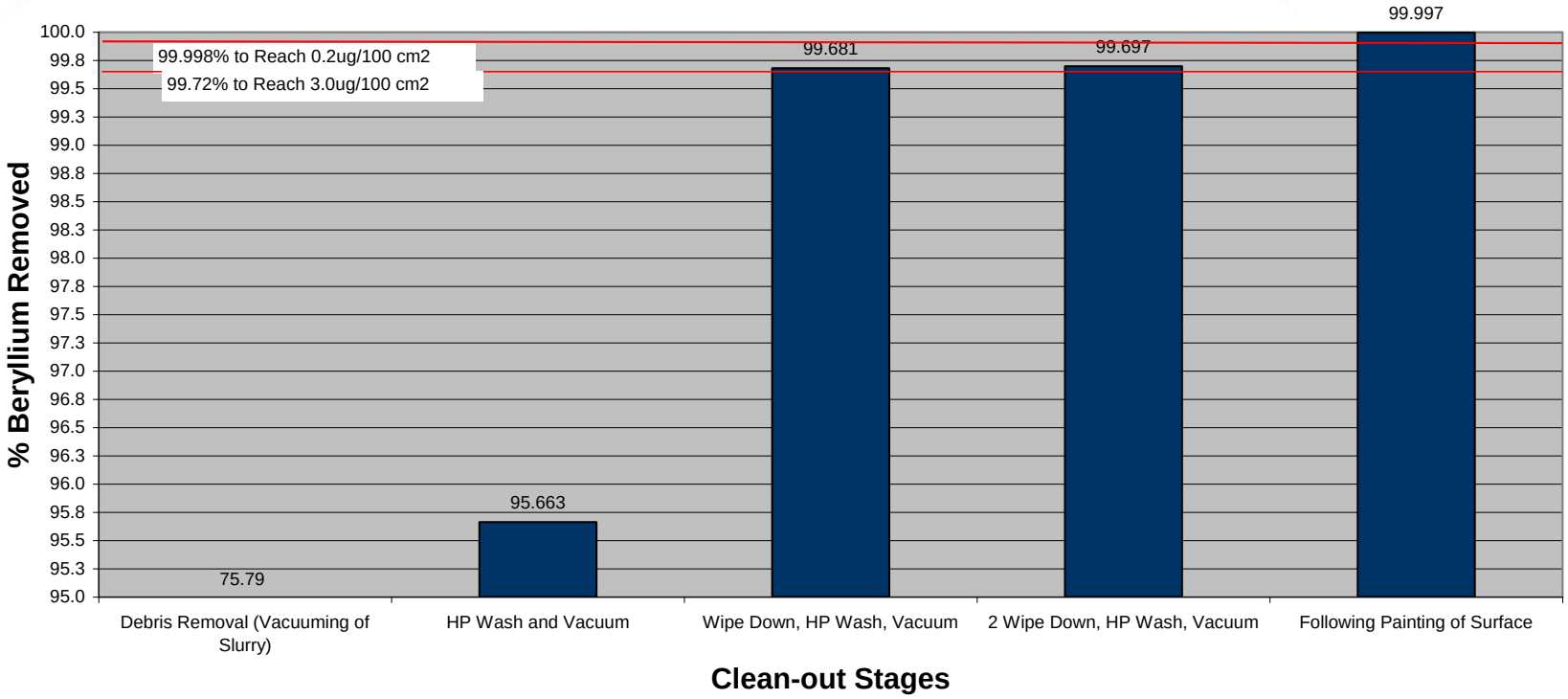
- Vessel Operations
  - Pull Top Cover and Exit Cover
  - Remove Contents
  - High Pressure Wash
    - Explored Wand System = Large Volume of Secondary Waste
    - Wasn't Effective
    - Longer Setup
  - Media Blast Surface
    - Many Iterations of Design
  - Grinding of Flaws
  - Pull Remaining Covers
  - Final Wipe Down
- Through Every Stage We Sample

Track Effectiveness of Process Stages

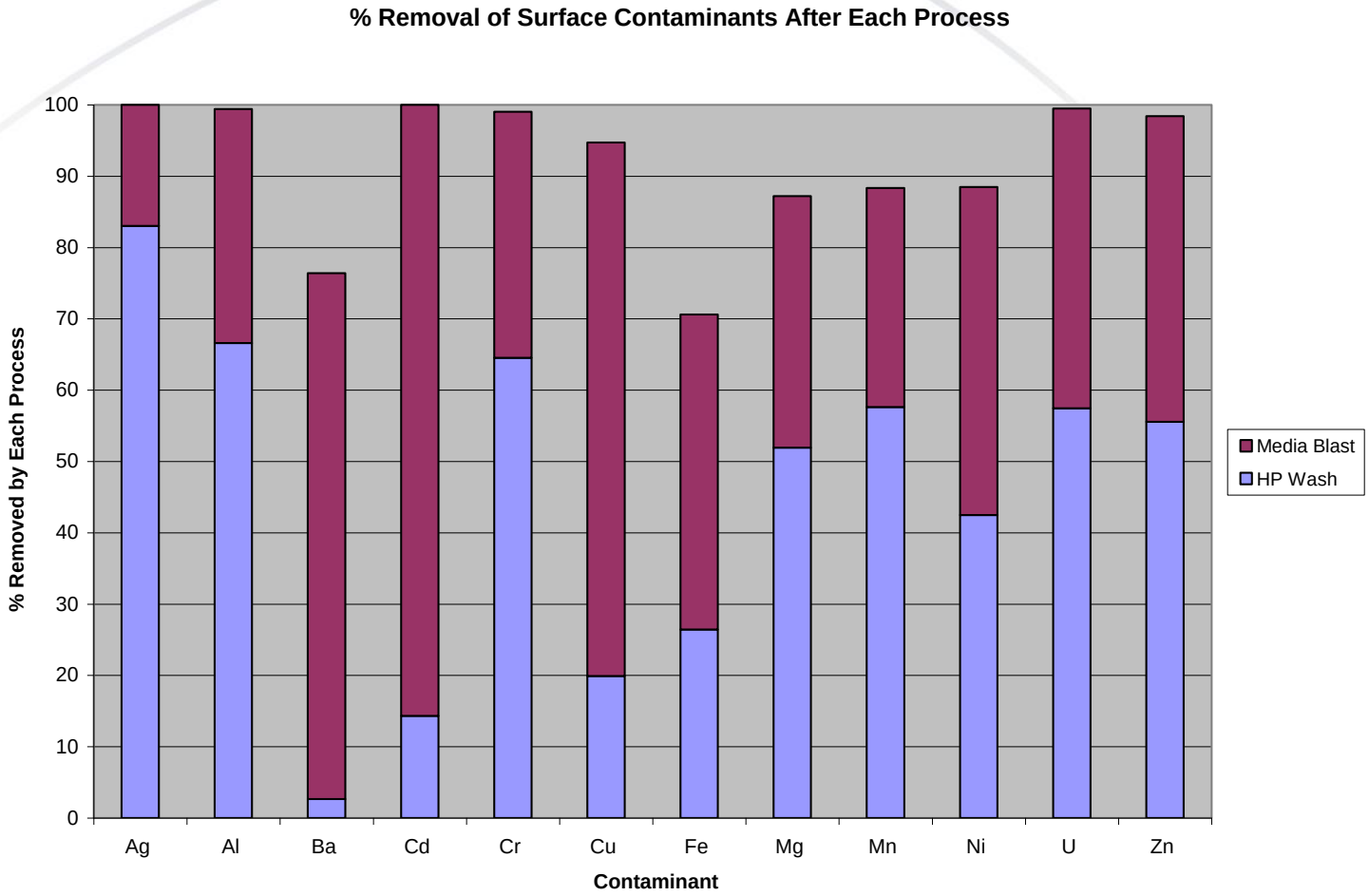
- SAP, Sampling and Analysis Plan
  - Sample the Vessel at Each Stage
  - Track Shot Constituents

Metal	Initial	HP Wash	Media Blast	Paint	Release Limit
Beryllium ($\mu g/100cm^2$)	91	5	0.5-ND	ND	0.2
Uranium (dpm)	60,000	3000	25	ND	1000

Initial Tracking: Firing Point Operations



Evaluate Various Metals



Media Blast System

- Black Beauty 12-20 mesh Coal Slag
- Schmidt 6.5 ft^2
  - Operating Around 70 psi/ 260 CFM
  - 500 lbs/hr
  - Pneumatic Remote
  - Nilfisk Vacuum Assist Head
  - Soft Brissle Cup
- Combine with Vector Vacuum
  - 1000 CFM

Media Blast Operations

- 3-4 Person Operations
  - Entrant Performing Blast
  - Attendant: Deadman Switch
  - Vacuum Attendant
  - Blast Pot Attendant
- Entrant/Attendant in Level II PPE, Hearing Protection
- Physically Enter Vessel
- Surface Contamination Goals
- Approximately 60 minutes
- Media Reports to Drum Collection

Lessons Learned

- Beryllium Exposure to Entrant
  - >0.2 µg/m^3
  - Reportable Incidents
  - Be Rule Doesn't Take into Account PPE
    - Initial Operation-Learning
    - Inadequate Vacuum Flow
    - Gun Design Change
    - New People
- Difficult Materials
  - HE Detonation Products
  - Fusing of Plastics
    - Easier to Remove Prior to Blast Operations

Future: Robotics

- Recognize Process Generate Airborne Particulates
  - Don’t Want Personnel Exposures
- Wolfe Robotics Integrated System
- ~ 3-4 hrs Cycle
- 1-2 hrs setup
- Remote Operations
  - Program and Leave
- Issues:
  - Facility to Small
  - Contamination Outside
  - Working the Issues

Covers and Hardware

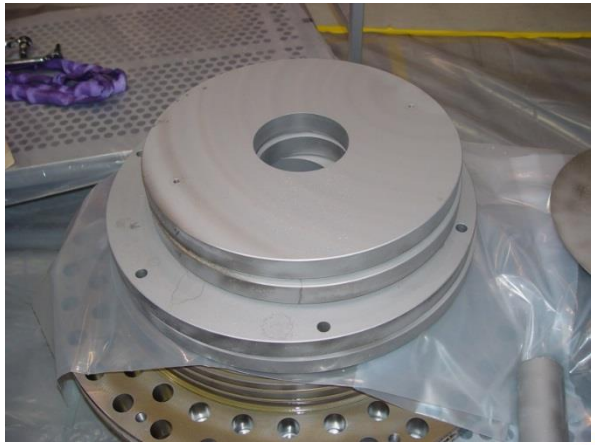
- Initial Design
  - Scrub by Hand
    - Downdraft Tables
  - Large Hood with HP Water
    - Nope! Levels too High
  - HP Parts Washer/Heated
    - Varied Cleaning Agents
    - Resulted in Large Volumes Waste Water
  - Collection Tank Systems Discharged

Wet Blasting Chamber

- Custom Built: Wet Technologies
  - Zr Based Media
  - Recycles Water
  - Plate Filter/Collection Pans
  - Automatic or Remote

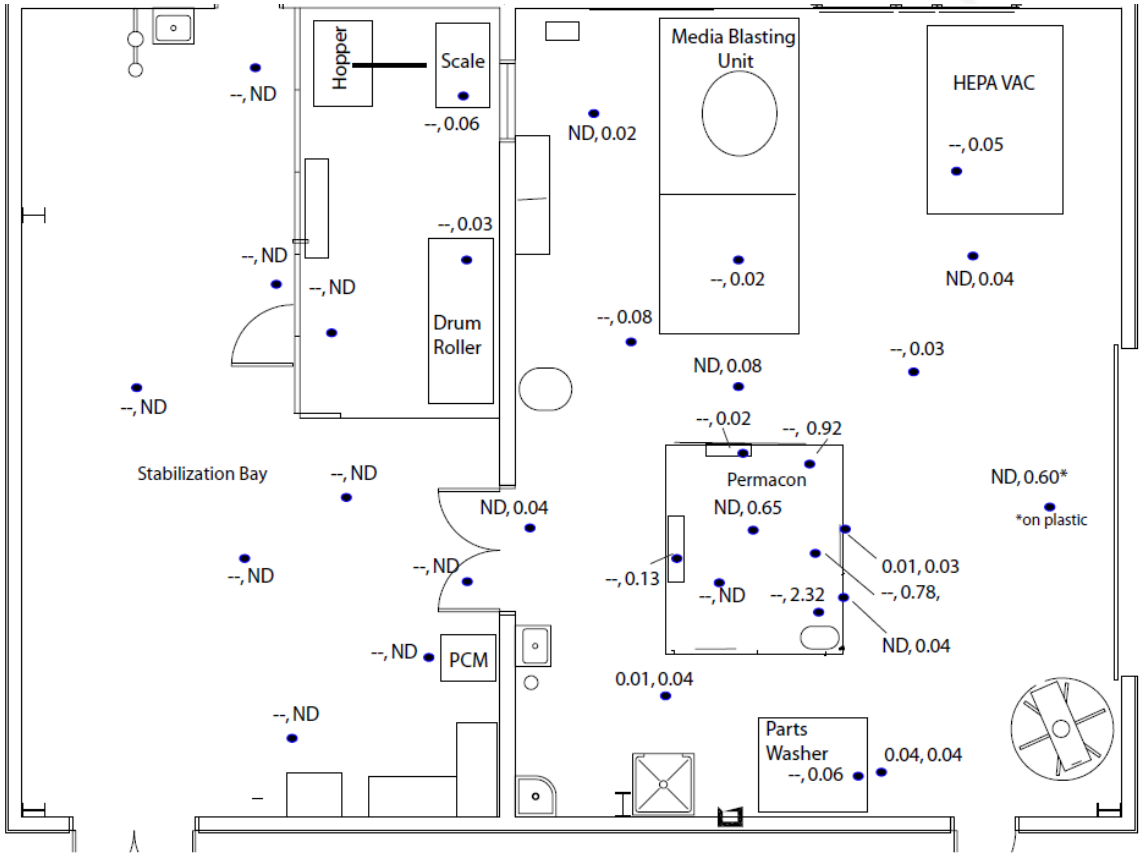
Performance

- Clean Surfaces
- Minimal Secondary Waste
  - Consolidate into Process
- Issues/Improvements
  - Orientation = Media in Holes
  - Plug Prior to Cleaning
  - Overflow issues with Fresh Water Rinses
  - Pre-blast Covers On Vessel
  - Weight Limit
    - Assembled Entry to Heavy
- Looking at New System



Track Contamination of Process Rooms

- Beryllium Surface Levels µg/100cm^2 Pre and Post Operations
- Process Improvements

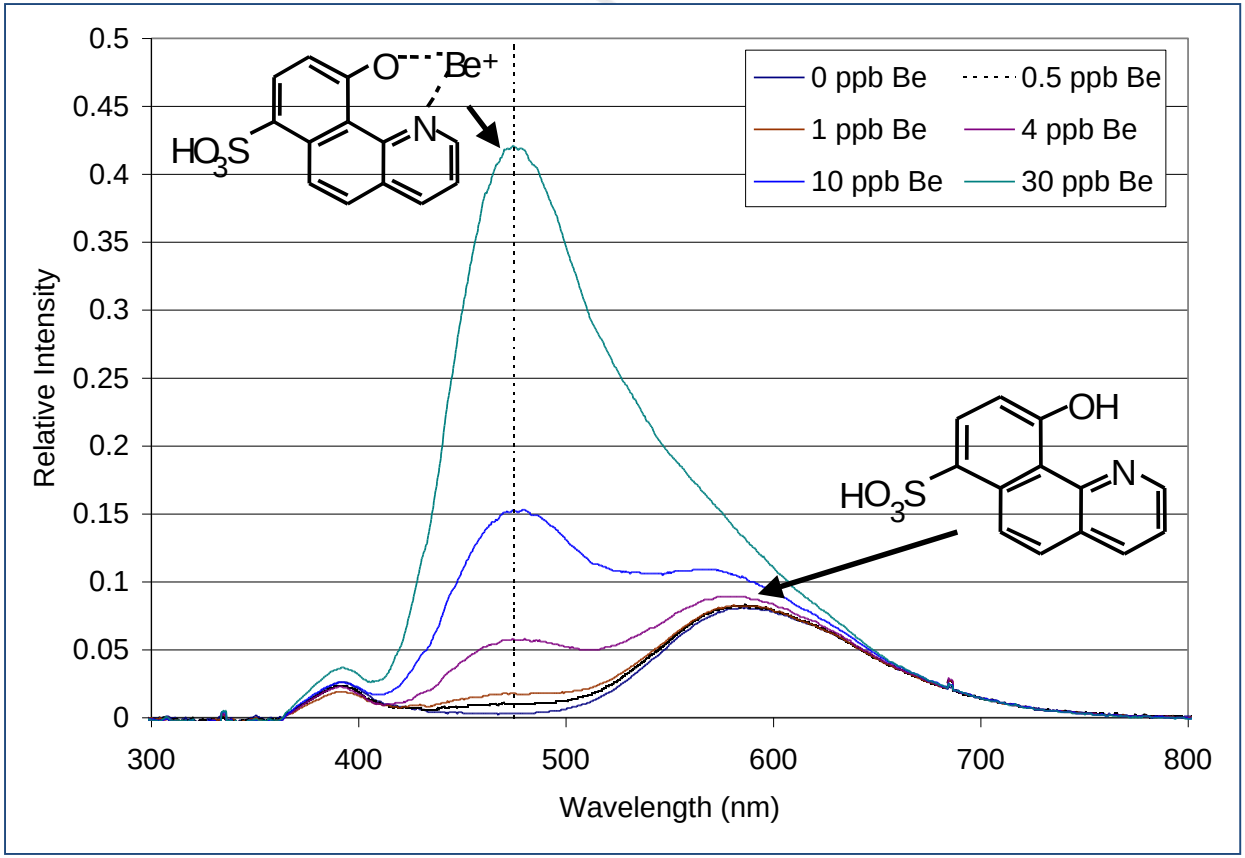


Release Hardware/Vessel

- Radiological Contamination Area
- Beryllium Contamination Area
- Survey Equipment for Release/Transfer
  - Radiological Smears and Direct Surveys
  - Beryllium-In House Analysis
  - Track Movement of All Vessel Hardware
  - <1000 dpm Rad
  - <0.2 µg/100cm^2
- Re-clean as Necessary: Paint to Seal Surfaces
- Equipment Becomes Designated “Inaccessible Beryllium Contaminated”
- Vessel Released from PPE Requirements
  - Fixed Radiological = Safety Glasses

Semi Real Time Analysis Be

- In-House Analysis; NIOSH 9110 and ASTM Approved Method
  - Developed by LANL in support of DARHT Operations
  - Quick Turn-Around (100 samples/hr)
  - Unaccredited use for Surface Contamination Only
- Berylliant Inc
  - Partnered to Supply HBQS



*Hydroxybenzoquinoline sulfonic acid (HBQS)

Track Exposures

- Area and Personal Air Monitors
  - Area: All Metals and Radiological
  - LPEL for Beryllium
- Collect Data for Each Process
  - Process Improve
  - Changed/Re-designed Equipment
  - Beryllium Main Driver
    - Action Levels reducing from 0.2 to 0.05 µg/m^3

LPEL Exposures

Day	Process	Personnel	Be µg/m3 8hr TWA	U µg/m3 8hr TWA
2	Removal of Lg Debris	Entrant Attendant Room Attendant	<0.009 <0.009 <0.009	<1.78 <7.67 <1.74
3	Removal, Mixing and Vacuum	Entrant Attendant Room Attendant	0.017 <0.009 <0.009	<1.74 <1.81 <1.74
4	Media Blasting	Entrant Attendant Room Attendant	0.084 <0.009 <0.009	5.8 <1.75 <1.803
5	Grinding Operations	Entrant Attendant Room Attendant	0.12 <0.009 <0.009	25.88 <1.77 <1.74
	Permissible Exposure Limit		0.2	200

Improvements in Design and Operations

Conclusions

- Processes We Evaluated
- Constantly Tracking Effectiveness
  - Contamination Levels and Exposures
- Continuous Process Improvements
  - Robotics Use Very Promising
  - Trade-off of Time
  - Fixing Issues

- Questions